# Shrinkproofing of Wool by Permanganate/Sodium Chloride Treatment

Masao HORIO, Chikaaki SAKAI, Takashi KONDO and Ken'ichi SEKIMOTO*

(Horio Laboratory)

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In the Sironized-process attention has been concentrated upon the shrinkproofing of wool yarns and fabrics, but it has been observed that many other practical properties are also considerably modified by the processing. Thirteen items relative to the practical properties of wool were measured using the yarns and fabrics which had been treated with potassium permanganate/sodium chloride and potassium permanganate/water, in comparison with the untreated yarns and fabrics. It is of interest to note that the marked changes in pilling, frictional property and dye-accessibility of wool were brought about besides shrinkproofing by the treatment with permanganate/sodium chloride. The treatment with potassium permanganate/water exerted always smaller effects. All these phenomena seemed to be correlated with each other, and could be related to the change in the surface condition of individual fibers.

The Sironized-process has been studied from the practical point of view. Further, some experiments have been done to interpret the action of sodium chloride in the processing liquor. According to McPhee[1,2] and Bradbury[3] the role which sodium chloride or other salts play in the processing is not simply comprehensible. So far as the present study is concerned, however, the shrinkproofing and various other effects brought about by the treatment with potassium permanganate in sodium chloride, seem to be due to the limitation of reaction to the outside of fibers.

The materials used are the knit yarns made from Merino 60's Count 4/16 (Sample 1), and the knit fabrics made therefrom (Sample 2).

The sample is immersed in 5*M* sodium chloride solution at room temperature for ten minutes. The liquor ratio is 20. 5% potassium permanganate on weight of wool is added, and the liquor is kept at 25°C for 10 minutes, then the temperature is raised up to 40°C. The permanganate is almost consumed in 20 minutes. The sample is washed with water, and the manganese dioxide deposited is removed by reducing it with 10% sodium sulphite on weight of wool for 30 minutes at 30°C. For comparison the permanganate/water system is used. In this case, sodium chloride solution is replaced by water, but other conditions are the same.

## 1. ITEMS MEASURED

A series of practical properties as given below were measured with three

* 堀尾正雄，坂井史明，近土 隆，関本健一

types of samples, that is—untreated samples, permanganate/sodium chloride treated samples and permanganate/water treated samples.

1. Tensile strength of yarns.
2. Elongation at break of yarns.
3. Alkali solubility.
4. Spectrophotometric measurement of whiteness.
5. Pilling.
6. Loss in weight.
7. Frictional behavior of fibers.
8. Rate of moisture regain.
9. Fastness of dyes against boiling, soaping, sweat, light and rubbing.
10. Rate of dye absorption.
11. Shrinkage of yarns.
12. Shrinkage of fabrics.
13. Load-elongation curves of felted yarns.

## 2. SHRINKAGE

The items given above will be described only in part briefly.

In Table 1 several properties before and after the treatment are shown in comparison. It is clearly seen in the table that the treatment with permanganate/sodium chloride system has good shrinkproofing effect.

Table 1. Properties of yarns treated with permanganate/sodium chloride in comparison with those of untreated yarns.

| | Untreated | Treated |
|---|---|---|
| Tensile strength (g.) | 1653 | 1597 |
| Elongation at break (%) | 47.1 | 45.2 |
| Shrinkage of yarn at pH 3 (%) | 48 | 13 |
| Shrinkage of yarn at pH 9 (%) | 42 | 9 |
| Shrinkage of yarn in 0.05% soap solution (%) | 50 | 17 |
| Decrease in fabric area in 0.05% soap solution (%) | 51 | 4 |
| Reflection at the wavelength of 400m$\mu$ (%) | 41 | 46 |
| Loss in weight (%) | 0 | 0.7 |
| Alkali solubility (%) | 9 | 11 |
| Frictional coefficient | | |
| $\mu_1$ (anti-scale) | 0.60 | 0.34 |
| $\mu_2$ (with-scale) | 0.26 | 0.22 |
| $\mu_1-\mu_2$ | 0.34 | 0.12 |

Figs. 1, 2 and 3 show the shrinkage of the yarns (Sample 1) as a function of time in different media, that is—in the solution buffered at pH 3 and 9, and in 0.05% soap solution, respectively. The shrinkage of yarns was measured by the method of van der Vegt[4] et al. as modified by us. It is insteresting to see that the yarn treated with potassium permanganate in 5$M$ sodium chloride solution is greatly shrinkproof, while potassium permanganate in water effects only a smaller shrinkproofing.

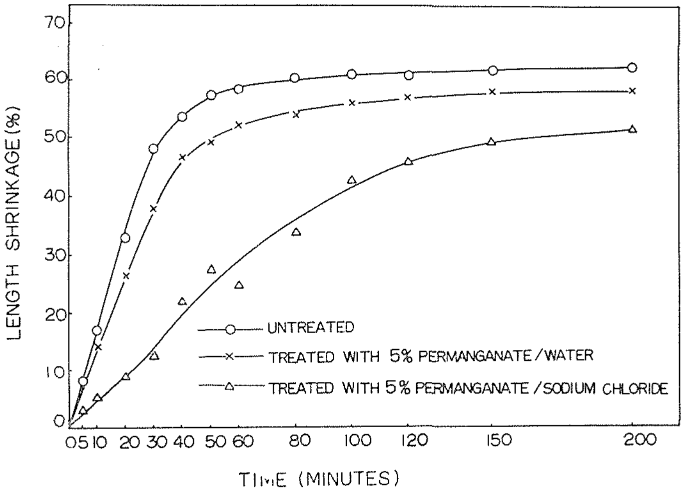


Fig. 1. Plots of shrinkage in the medium buffered at pH 3 vs. time for the yarns treated by 5% potassium permanganate on weight of wool in 5*M* sodium chloride and for the yarns treated by the same amount of potassium permanganate in water, in comparison with the plots for the untreated yarns.

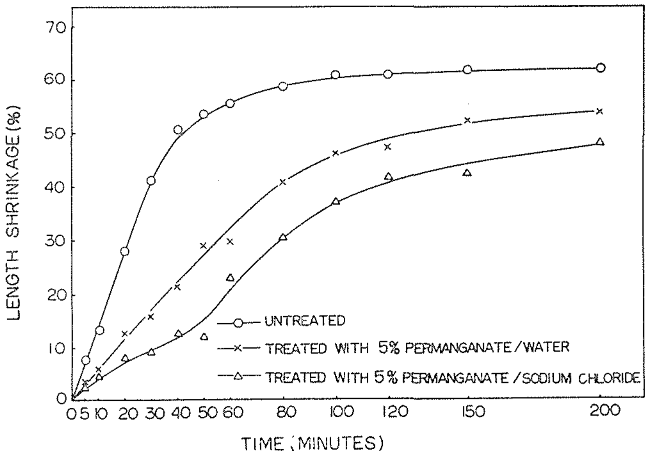


Fig. 2. Plots of shrinkage in the medium buffered at pH 9 vs. time for the yarns treated by 5% potassium permanganate on weight of wool in 5*M* sodium chloride and for the yarns treated by the same amount of potassium permanganate in water, in comparison with the plots for the untreated yarns.

Fig. 4 shows the change in the area of the fabric (Sample 2) after washing at 40°C. The wash liquor contains 0.3% of soap, 0.2% of sodium carbonate, and the liquor-fabric ratio is 300 : 1. The washing was performed in a vessel under vigorous agitation, using a washing machine. The treatment with potassium permanganate in sodium chloride solution results in a great shrinkproofing.

### 3. PILLING

Of much interest is the change in pilling behavior, which is shown in Fig. 5.

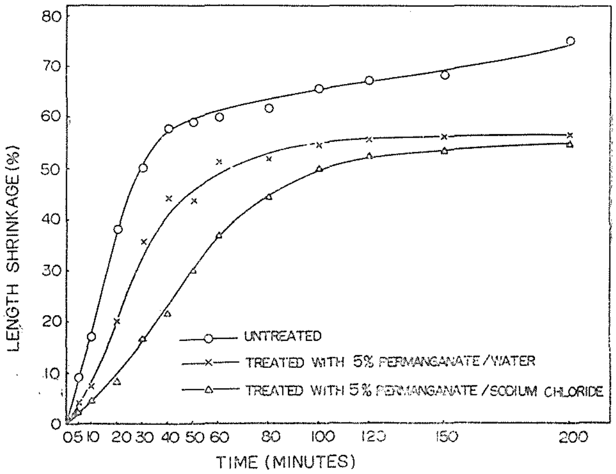


Fig. 3. Plots of shrinkage in 0.05% soap solution vs. time for the yarns treated by 5% potassium permanganate on weight of wool in $5M$ sodium chloride and for the yarns treated by the same amount of potassium permanganate in water, in comparison with the plots for the untreated yarns.

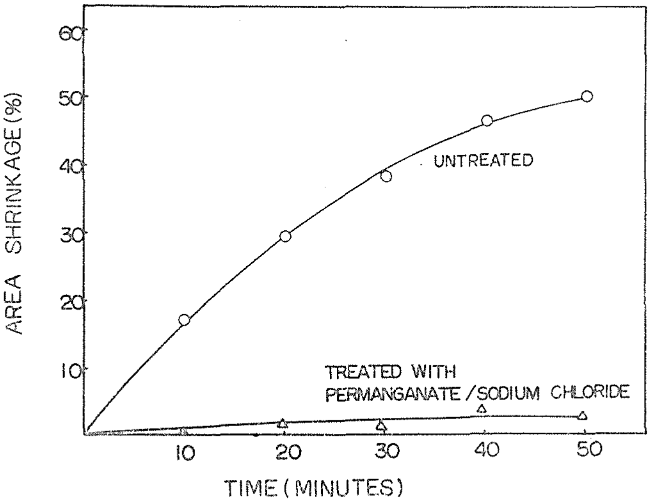


Fig. 4. Change in area after washing with soap solution vs. time of the fabric treated by 5% potassium permanganate on weight of wool in $5M$ sodium chloride in comparison with that of the untreated fabric.

Experiments were done with a "random tumble pilling tester" of Atlas Co., Ltd. Photos. 1 and 2 of Fig. 5 show the original fabric after pilling tests, while Photos. 3 and 4 show the treated fabric after the same tests. This series of photographs shows that the pilling behavior is remarkably improved by the treatment. The loss in weight during the testing is very small in either case. Therefore, it is suggested that the change in pilling would be due to the change in surface character of fibers constructing the fabric.

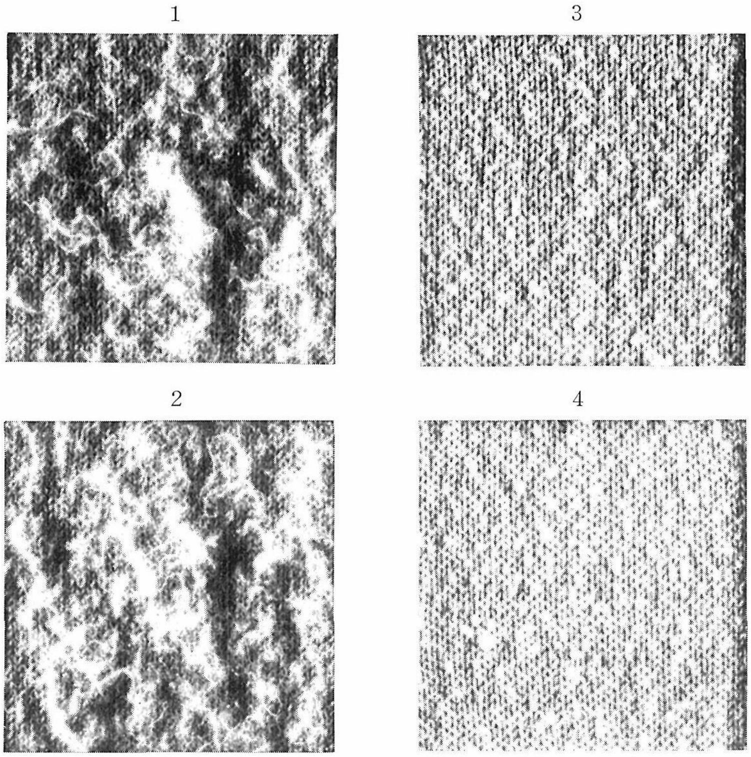

Fig. 5. Result of pilling tests. Photos. 1 and 2 show the surfaces of the untreated fabrics after pilling tests for 15 min. and 30 min., respectively. Photos. 3 and 4 show the surfaces of fabrics treated by 5% potassium permanganate on weight of wool in 5*M* sodium chloride after pilling tests for 15 min. and 30 min., respectively.

## 4. FRICTIONAL BEHAVIOR

Measurement was made of static frictional coefficients between a fiber and a mass of fibers. A metallic cylinder was covered uniformly with a top of 60's Merino wool. The fiber to be tested was hung over the wool-covered cylinder. A 100mg. weight was fixed at each end of the fiber. One end was connected with an arm of a torsion balance, which pulled up the weight until the fiber began to slip over the cylinder. The anti-scale coefficient $\mu_1$, and the with-scale coefficient $\mu_2$ were measured, and the directional property was expressed by $\mu_1$-$\mu_2$. As can be seen in Table 1, the change in the with-scale coefficient ($\mu_2$) is very small, but the anti-scale coefficient ($\mu_1$) decreases markedly by the permanganate/sodium chloride treatment and therefore, the value of $\mu_1$-$\mu_2$ becomes apparently smaller. This suggests that there occurred the considerable change in the surface condition of the fiber by the treatment, and is consistent with the production of shrinkproofing effect and the improvement of pilling character.

On the other hand, in the case of permanganate/water system which does not effect the shrinkproofing, the change in $\mu_1$ is not so marked, and the values of $\mu_1$-$\mu_2$ are greater than those of fibers treated with permanganate/sodium chloride system.

## 5. DYE ABSORPTION

A marked difference in the rate of dye absorption can be seen between the untreated yarns and the treated yarns, as shown in Figs. 6 and 7. Two kinds of dyestuffs, that is —Ponceau Crystal and Carbolan Brilliant Green 5G were employed. The treatment of yarns with permanganate in sodium chloride solution brings

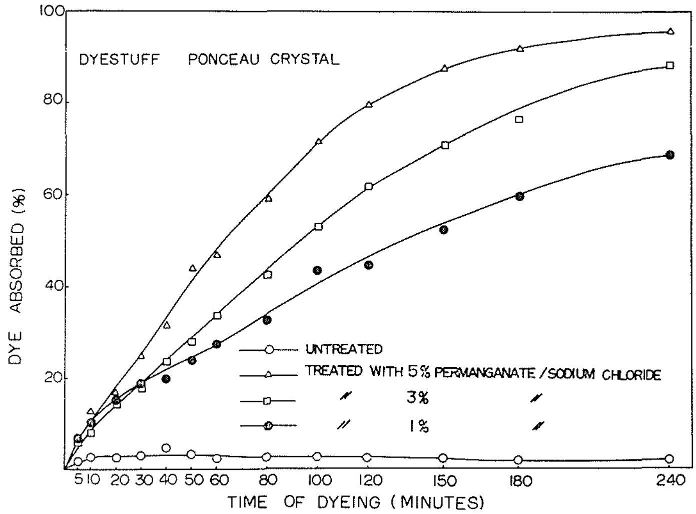


Fig. 6. Plots of dye absorption vs. time for fibers treated with potassium permanganate in 5$M$ sodium chloride in comparison with that for untreated fibers. The amount of potassium permanganate is varied, 1%, 3% and 5% on weight of wool. The dyestuff used is Ponceau Crystal.

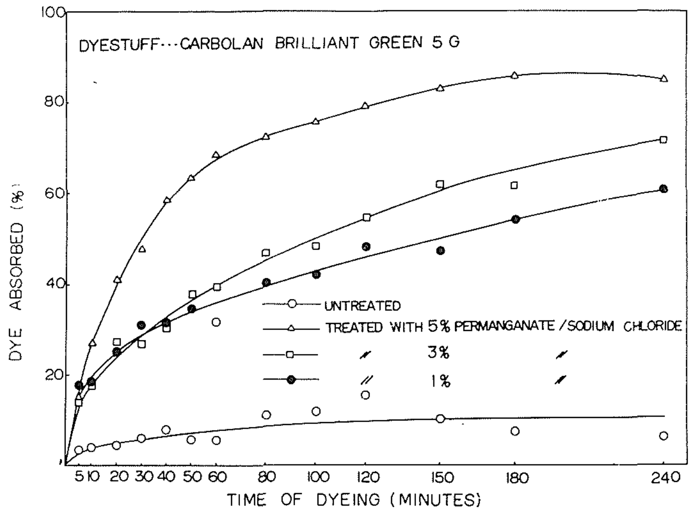


Fig. 7. Plots of dye absorption vs. time for fibers treated with potassium permanganate in 5$M$ sodium chloride, in comparison with that for untreated fibers. The amount of potassium permanganate is varied, 1%, 3% and 5% on weight of wool. The dyestuff used is Carbolan Brilliant Green 5G.

about a great increase in dye-accessibility, and indeed the effect is the greater as the amount of permanganate applied upon wool is increased.

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